

VOLTAGE REGULATORS

CR7930-NA105 AND TYPE GNA-13

INTRODUCTION

The CR7930-NA105 and Type GNA13 voltage regulators described in this instruction book are used to control the a-c voltage output of amplidyne booster inverters. A set is used to generate a-c power from a variable voltage d-c power supply, such as a storage battery.

The diagrams included in these instructions are for illustrative purposes. When installing, adjusting, or servicing this equipment, always refer to the diagrams supplied separately with the equipment.

HANDLING AND STORAGE

The CR7930-NA105 and Type GNA13 voltage regulators are static regulators and have no moving parts. This permits very rugged construction and enables the units to function satisfactorily where considerable vibration is present. However, the regulators are also precision instruments and should be handled carefully. Severe shocks caused by dropping or being struck by other objects will damage the regulators.

The regulators should be stored in a clean, dry place where the temperature will not exceed 125 F. Avoid stacking the regulators against radiators or steam pipes or in very humid atmospheres.

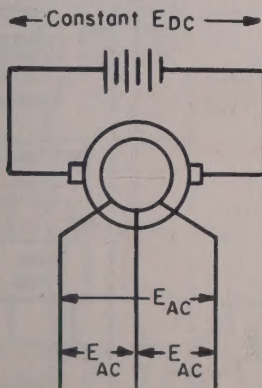


Fig. 1 Functional diagram

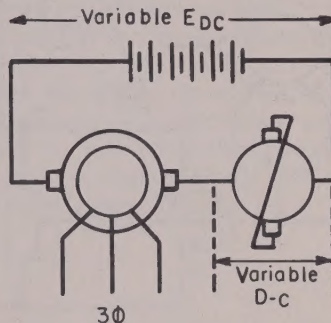


Fig. 2 Functional diagram with amplidyne

DESCRIPTION

GENERAL

The amplidyne booster inverter consists of two separate machines mechanically coupled together. One machine is an inverter which converts d-c to a-c, and the other machine, a special type of d-c machine, is called an amplidyne.

If, as in Fig. 1, a small inverter is connected across a battery of infinite capacity, there is a definite relationship between E_{DC} and E_{AC} . No external regulation of this system would be required, and the a-c voltage would remain reasonably close to normal as the inverter supplies a-c power up to the rating of the machine.

If the battery is relatively small, and its voltage changes appreciably from full charge to discharge, and if the a-c load supplied by the inverter requires essentially constant a-c voltage, the system in Fig. 1 is not practical since variable d-c voltage necessarily means variable a-c voltage.

This system will function to provide a-c voltage within close limits if a variable-voltage source is introduced between the inverter armature and the battery to compensate for changes in battery voltage. In this system, Fig. 2, an amplidyne which is mechanically coupled to the inverter, with its armature in series with the inverter armature and battery, is the variable d-c voltage source used to compensate for battery-voltage variations.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

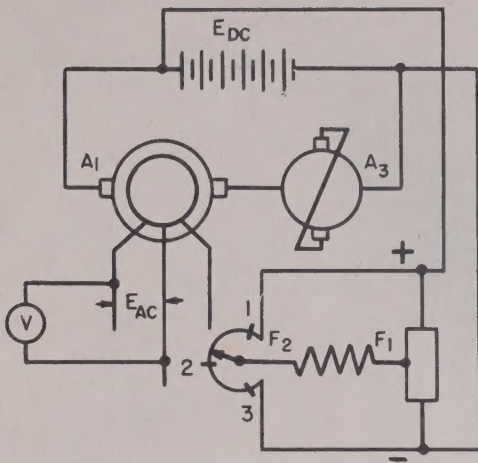


Fig. 3 Functional diagram with amplidyne and manual control

The amplidyne is a special form of d-c machine. A principal difference between an amplidyne and the conventional d-c shunt machine, from a control consideration, is the difference in excitation wattage required. The excitation wattage required for an amplidyne is only a fraction of the wattage which a conventional d-c machine requires. Because of this, an amplidyne can be more easily controlled.

One way to control the inverter a-c voltage is by manual means, as shown in Fig. 3. When the battery voltage is high, the potentiometer will be in some position between 1 and 2, which results in current flowing through the amplidyne field from F2 to F1. This causes the amplidyne voltage to buck the battery voltage so that the resultant d-c voltage to the inverter is sufficient to produce normal a-c voltage. When the battery voltage has dropped to the value which will produce normal inverter a-c voltage, the potentiometer is turned to point 2, so that no current will flow through F1-F2. When the battery voltage is low, the potentiometer is turned to some position between 2 and 3, so that current flows from F1 to F2. This causes the amplidyne generated voltage to add to the battery voltage. The resultant d-c voltage across the inverter is sufficient to produce normal a-c voltage.

However, the use of a hand rheostat requires the constant attention of an operator and from this standpoint is unsatisfactory.

Either a CR7930-NA105 or a Type GNA13 voltage regulator automatically controls the excitation of an amplidyne and thus automatically adjusts the d-c voltage across the inverter to control the a-c voltage output as the inverter load changes from zero to full load and the battery voltage varies from maximum to minimum value. See Fig. 4.

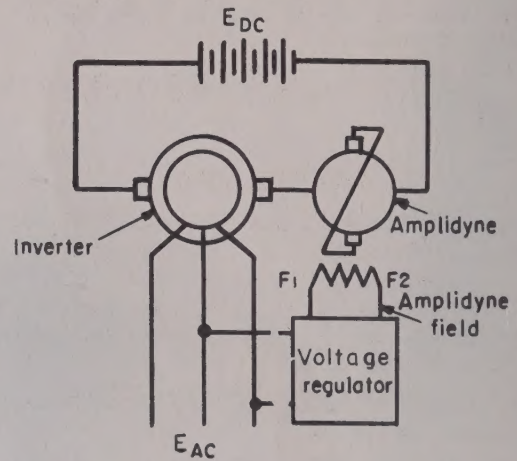


Fig. 4 Functional diagram with amplidyne and voltage regulator

The voltage regulator is a single unit which contains all static components (capacitors, reactors, rectifiers, and transformers) required for automatic control. The major functional components of the regulator, shown in Fig. 5, consist of: a nonlinear circuit containing a saturated reactor which determines regulator sensitivity and voltage level; a linear circuit which provides a reference voltage; a comparison circuit in which the nonlinear and linear voltages are compared and the net resultant current fed to the amplidyne field; an antihunt or

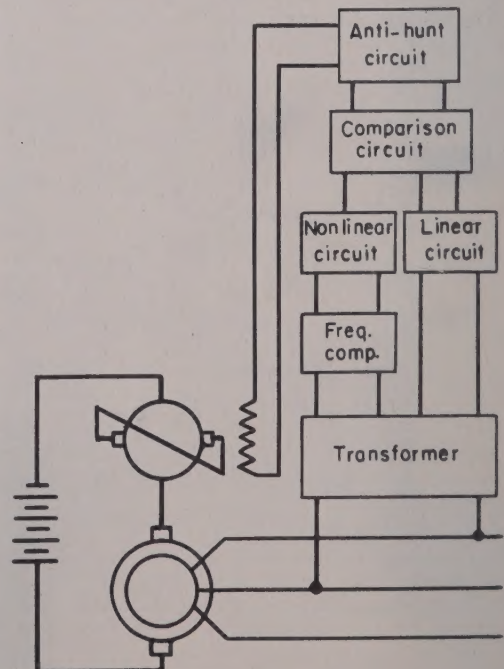


Fig. 5 Block diagram of voltage regulator

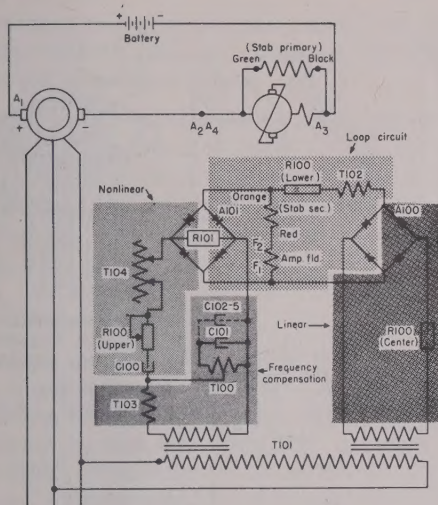


Fig. 6 Connection diagram of voltage regulator

stabilizing means which damps out or prevents sustained voltage oscillations; and a frequency-compensation circuit.

These circuits are shown in Fig. 6 which is the connection diagram for the complete regulating circuit. Transformer T101 in Fig. 6 is used to transform the inverter a-c voltage to the correct voltage required by the regulating circuits.

Note that the R100 resistor assembly is composed of an upper, a center, and a lower resistor, each being connected in a different regulator circuit.

CONDITION	PREDOM. CIRCUIT	DIRECTION AMP. FLD. CURRENT	AMP. POL.	RESULT
Battery low (no load)	Linear	F ₂ to F ₁	A ₃ +	Amp adds to bat. increasing voltage across inverter
Battery low (load applied)	Linear	F ₂ to F ₁	A ₃ +	Amp adds to bat. increasing voltage across inverter
Battery voltage high	Non-linear	F ₁ to F ₂	A ₃ -	Amp opposes bat. decreasing voltage across inverter

NONLINEAR CIRCUIT

The nonlinear circuit is a series-resonant circuit composed of saturated reactor T104, variable resistor R100 (upper), capacitor C100, and rectifier A101.

The characteristics of this circuit are best described by reference to Fig. 7, which shows a series-resonant circuit supplying a d-c load from a variable a-c supply. As the a-c voltage is slowly raised from zero to some value near normal, the relationship between a-c voltage and direct current is linear. At some point near normal voltage, the curve breaks sharply, and a small change in a-c voltage results in a large change in direct output current. This phenomena can be used for regulation of an a-c voltage, since on the flat portion of the curve a small change in a-c voltage results in a large change in direct current. See Fig. 8.

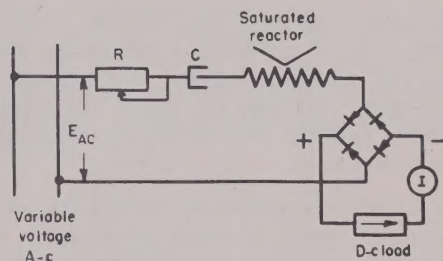


Fig. 7 Nonlinear circuit

A second characteristic of this circuit is the change in slope of the flat portion of the saturation curve when the value of resistance (R) is changed, Fig. 9. If the resistance of R is high, the slope of the curve is steeper (regulator less sensitive). As R is decreased, the slope becomes flatter (regulator more sensitive since a relatively smaller change in a-c voltage results in a greater change in d-c output). It should be noted that changing R, in addition to changing the slope, slightly changes the a-c level which the regulator will hold.

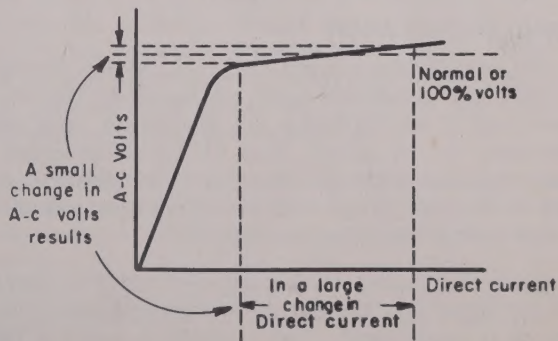


Fig. 8 Nonlinear circuit characteristics

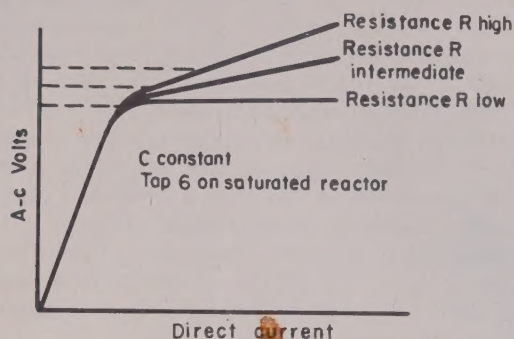


Fig. 9 Nonlinear circuit characteristics showing how slope of curve varies with resistance

The third characteristic of this circuit is the change in level of the whole curve as the number of turns on the saturated reactor are varied, R being held constant. See Fig. 10. Thus, changing taps on the reactor will set the a-c voltage level which the regulator will hold.

The fourth characteristic is the frequency response of the circuit. When the frequency is lowered, the whole saturation curve is proportionately lowered; that is, for five percent lower frequency the a-c voltage for a given direct-current output is five percent low. See fig. 11. For an a-c voltage regulator this is undesirable, since this means that a change in frequency will affect the voltage which the regulator will hold. Therefore, a frequency-sensitive circuit must be used with the nonlinear circuit to counteract this frequency effect. This will be described later.

LINEAR CIRCUIT

The linear circuit consists of a resistor R100 (center) and a dry-type rectifier A100 which has its a-c voltage supplied from an isolating winding on T101. The characteristics of this circuit are shown in Fig. 12. As the name implies, the relationship of applied a-c voltage to d-c output is linear.

COMPARISON CIRCUIT

The comparison circuit, Fig. 13, is the circuit in which the direct currents produced by the nonlinear and linear circuits are compared, and the difference fed to control field F1-F2 of the amplidyne. Reactor T102 and resistor R100 (lower) are used to smooth out the rectified d-c ripple and also to load up the rectifier loop circuit.

It should be noted that the rectifiers of both linear and nonlinear circuits are connected additive (voltage not in opposition). This makes it possible for this circuit to cause current flow through the amplidyne control field from F1 to F2 or from F2 to F1.

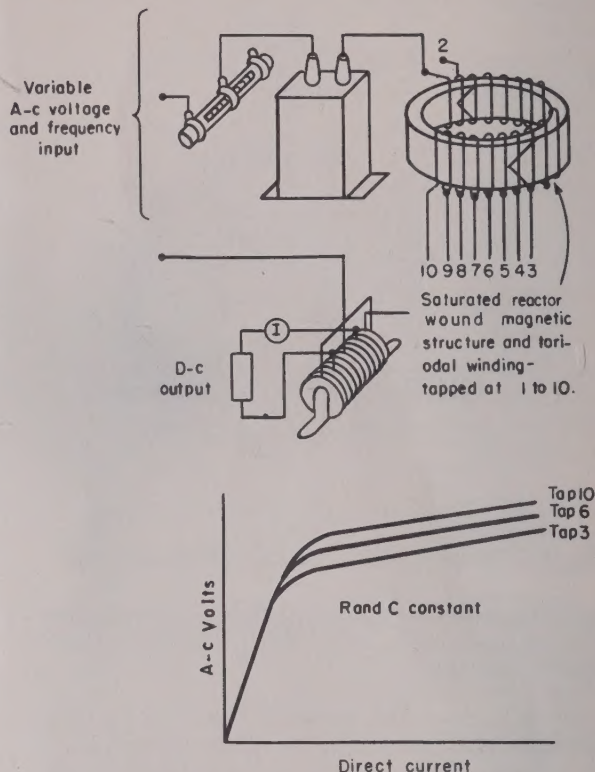


Fig. 10 Nonlinear circuit characteristics showing how level of curve is changed by saturated reactor

This is necessary since changing the direction of current flow through the amplidyne control field changes the polarity of the amplidyne armature and, as described earlier, the amplidyne must reverse polarity as the battery voltage changes from maximum to minimum if the regulator is to hold inverter a-c voltage.

If the a-c voltage from the nonlinear circuit is higher than the voltage supplied by the linear circuit, the difference in current produced flows from F1 to F2.

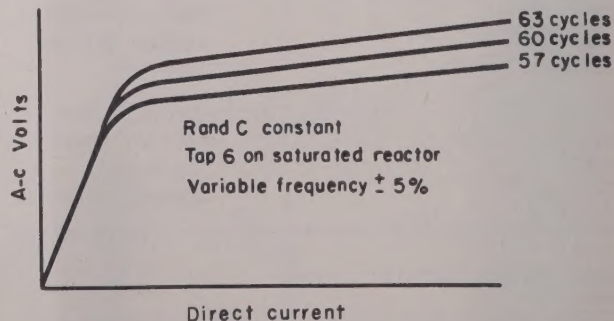


Fig. 11 Nonlinear circuit characteristics showing how level of curve changes with frequency

If both a-c voltages are the same, the currents circulate through the loop and no current flows through the amplidyne field.

If the a-c voltage from the nonlinear circuit drops below the voltage from the linear circuit, the linear-circuit current predominates, and the difference between it and the current from the nonlinear circuit flows through the amplidyne field from F2 to F1. See Fig. 14a, b, c.

STABILIZING CIRCUIT

Sensitive regulating circuits must have some means of stabilizing if excessive and sustained oscillations in the system are to be prevented. This is achieved by the stabilizing or antihunt transformer S100. The primary is connected across the amplidyne armature and the secondary is connected in series with amplidyne control field F1-F2. The secondary is so connected that any voltage induced in it opposes slightly any change in F1-F2 initiated by the regulator.

If load is suddenly applied to the inverter, the regulator causes the amplidyne to increase the net d-c voltage across the inverter by increasing the amplidyne control-field current. If no stabilizer were present, the regulator would force the amplidyne field current when the a-c voltage rose close to normal. The result would be a violent voltage overshoot, which would cause the regulator to rapidly try to force the a-c voltage down. This would result in violent a-c voltage oscillations known as hunting.

With the stabilizer connected, a rate-of-change voltage proportional to the amplidyne armature voltage rate-of-change is introduced by the stabilizer secondary into the amplidyne field. This induced voltage slows down the forcing due to the regulator when the a-c voltage approaches normal, and results in the a-c voltage steadying out with one or two small oscillations.

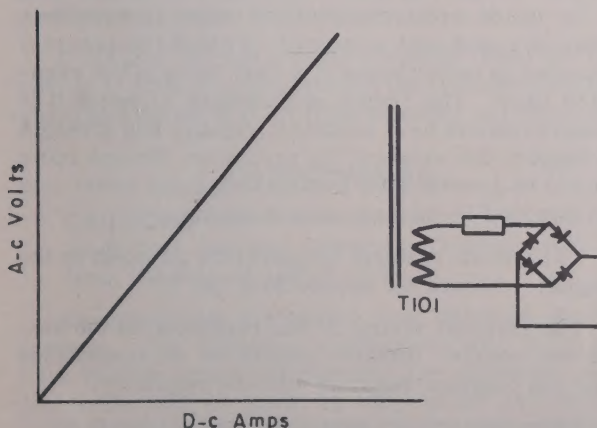


Fig. 12 Linear circuit characteristics

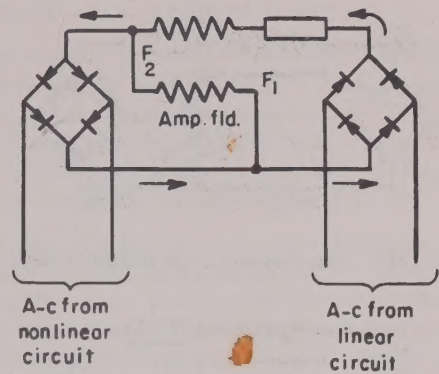


Fig. 13 Connection diagram of comparison circuits

The stabilizer acts only when there is a change in amplidyne voltage. Therefore, under steady-state conditions, there is no voltage effect due to the stabilizer in the system, and for this reason, the stabilizer has no effect on regulator steady-state sensitivity.

FREQUENCY-COMPENSATION CIRCUIT

If the amplidyne inverter produced a-c, with no frequency variation over the range of battery voltage variation and no load to full load on the inverter, frequency compensation would not be required. However, since the frequency does vary appreciably, and since this is reflected in the voltage held by the regulator due to the characteristics of the saturated reactor, some compensating circuit must be interposed between the regulator input and the nonlinear circuit if the regulator is to hold voltage within specification limits with variable frequency.

The frequency-compensation network consists of series reactor T103, and a parallel resonant circuit consisting of reactor T100 and capacitors C101 to C105 inclusive. The last three capacitors are trimmers for adjustment purposes. Note: This adjustment is made at the factory and should not be altered.

The inverter voltage is normally 100 percent at 60 cycles. If no frequency compensation were present, and nothing changed except that the frequency were raised to 63 cycles, the regulator would hold 105 percent voltage. Similarly, if the frequency were lowered to 95 percent or 57 cycles, the regulator would hold 95 percent voltage.

With frequency compensation interposed between the input to the nonlinear circuit and the voltage to be regulated, at 100 percent inverter terminal volts, 60 cycles, the output of the frequency-compensation network is also 100 percent of terminal voltage. The regulator holds 100 percent terminal voltage.

If the frequency is raised to 63 cycles, the inverter terminal volts are 100 percent into the fre-

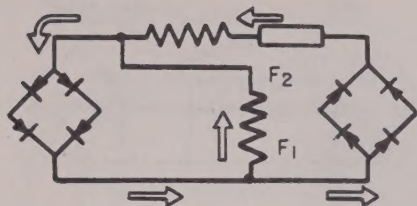


Fig. 14a Nonlinear circuit predominates

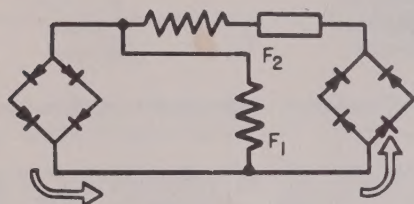


Fig. 14b Nonlinear and linear circuit voltages equal

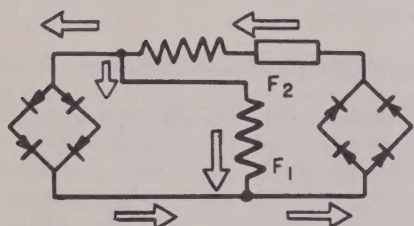


Fig. 14c Linear circuit predominates

quency-compensation network, but the output of the network to the regulator nonlinear circuit is 105 percent voltage. Therefore, with the network, even though the frequency is low, the regulator holds 100 percent because of the action of the network to present a 105 percent voltage at 63 cycles to the nonlinear circuit with an inverter terminal voltage of 100 percent.

Conversely, if the frequency drops to 57 cycles, with 100 percent inverter terminal volts to the frequency-compensation network, the output of the network to the regulator nonlinear circuit is 95 percent, which results in normal inverter a-c voltage even though the frequency is five percent low.

COMPLETE CIRCUIT

From Fig. 14a, b, c, it should be noted that when the nonlinear circuit voltage predominates, current flows through the amplidyne field from F1 to F2 (F1 positive); when the nonlinear circuit voltage drops so that the boost voltage predominates, current flows from F2 to F1 (F2 positive); and when amplidyne field F1 is positive, A3 of the amplidyne armature is negative (when F1 is negative, A3 is positive).

Figure 6 shows how the regulator acts to hold a-c voltage as the battery voltage varies from low to high, and as the a-c inverter load varies from no load to full load.

When the battery voltage is low, the a-c voltage will be low if the regulator does not function. In response to low a-c voltage, the linear circuit voltage predominates, forcing current from F2 to F1 through the amplidyne field. This makes A3 of the amplidyne armature increasingly positive, adding to the battery voltage and raising the d-c voltage across the inverter until the a-c voltage is normal.

If a-c load is applied to the inverter, the a-c voltage drops due to internal voltage drops in the a-c and d-c power system components. The nonlinear voltage is low due to low a-c inverter voltage, so the linear field predominates, forcing more current from F2 to F1 through the amplidyne. This makes A3 of the amplidyne even more positive than at no load, which results in higher d-c voltage across the inverter. The regulator keeps increasing amplidyne field current until the battery voltage plus amplidyne voltage is sufficient to produce normal a-c inverter voltage.

The load is removed and the battery voltage is raised to the maximum. If the regulator did not act, the a-c voltage would be high. When the a-c voltage to the regulator is high, the nonlinear circuit voltage predominates. This forces current through the amplidyne field from F1 to F2, making A3 of the armature negative, and opposing the battery voltage. The d-c voltage to the inverter, battery voltage minus amplidyne voltage, reduces. The regulator makes A3 increasingly negative until the d-c voltage to the inverter is reduced to a value sufficient to produce normal a-c voltage.

INSTALLATION

The voltage regulator is designed for mounting in an inside protected location which is relatively clean, dry, and well ventilated. It should be securely mounted by bolts through the four holes in the regulator base. The frame or bulkhead to which it is mounted should be of sufficient rigidity and strength to support the weight of the regulator. Enough room should be provided so that the regulator cover can be removed for inspection and wiring.

The normal ambient temperature adjacent to the regulator should not exceed 35 C (95 F).

The external wiring of the regulator to the amplidyne booster inverter should be in accordance with the diagram supplied with the regulator.

After connections have been made to the terminal board E100, a ground test should be made. Use a 600-volt Megger or similar instrument and test

from terminal No. 1 of E100 to the regulator frame. Make a similar test from terminal No. 6 to the frame. If any grounds exist, they must be removed.

OPERATION

When the regulator has been installed, start the amplidyne booster inverter in accordance with the separate instructions covering the over-all equipment. The inverter speed and voltage should increase to approximately rated values. The a-c voltage should be immediately measured; if it is higher than the a-c voltage rating stamped on the regulator nameplate, the regulator should be adjusted as described under "Adjustment."

With the correct a-c voltage, the frequency must then be measured. If the frequency is not correct, the inverter speed must be adjusted as described in the separate instructions covering this equipment.

When adjustments are completed, the a-c voltage and frequency should agree with the values given on the regulator nameplate when the booster inverter is supplied with the nominal value of d-c voltage, which is the mean of the maximum and minimum d-c voltage for which the booster inverter is rated.

If it is desirable, and if the voltage-adjusting range permits, the regulator may be operated at voltages and frequencies as much as five percent below the regulator rating, with an average d-c voltage applied to the booster inverter. However, the regulator must never be operated at voltages or frequencies greater than those for which the regulator is rated.

After the initial adjustments are completed, the d-c voltage applied to the inverter may be varied over the allowable range, and load may be placed on the inverter. The regulator should automatically maintain the voltage within reasonable limits. If the voltage change is beyond allowable limits, it may be possible to increase the regulator sensitivity as described under "Adjustments."

If the a-c voltage should oscillate when the inverter is first started, refer to the trouble-shooting chart and the section covering stability adjustments.

ADJUSTMENTS

CAUTION: Make all adjustments with the amplidyne booster inverter disconnected from the battery and at rest.

All regulators are tested and adjusted at the factory. The following instructions are given in case further minor adjustments are required. Adjustments may be made by varying the resistance of R100 (upper) or by changing taps on the saturated reactor T100.

SENSITIVITY AND STABILITY (R100)

If the regulated voltage over the range of battery voltage and from no load to full load is too great, cut out a small amount of resistance of R100 (upper). As previously explained, this will flatten the non linear circuit-saturation curve and make the regulator more sensitive, or hold closer voltage.

It is possible that if too much resistance is cut out of R100 (upper), the system will become unstable and result in a-c voltage oscillations. Therefore, this adjustment should be made judiciously, cutting out just enough resistance so that the regulator holds voltage within acceptable limits.

If the a-c voltage hunts or oscillates, cut in some resistance of R100 (upper).

As explained in the "Description," changing R100 (upper) slightly affects the voltage level. If the regulator band of regulated voltage is within limits and the system stable, but the voltage level held is either high or low, correction should be made by changing taps on reactor T104.

Resistance R100 is an assembly of several resistors, these resistors being used in different parts of the regulator circuit. One resistor is connected in the nonlinear circuit and is used for adjustment of sensitivity and stability. As previously described, this resistor may be readily identified since it is the only adjustable resistor in the regulator, and is the upper resistor in the assembly.

SATURATED REACTOR VOLTAGE LEVEL (T104)

The a-c voltage maintained by the regulator may be adjusted by changing the connections of the saturated reactor T104. This provision is made so the regulator may be adjusted to maintain the a-c voltage for which it is rated, the rated voltage being given on the regulator nameplate. It is also possible to adjust the regulator to maintain other values of a-c voltage which are slightly above or below the rated value. However, the regulator must not be adjusted so that an a-c voltage, greater than that for which the regulator is rated, will exist under any normal operating condition, including the condition of maximum d-c voltage with no a-c load on the inverter.

The a-c voltage maintained by the regulator may be increased by increasing the number of saturated reactor turns in the circuit, and may be decreased by decreasing the saturated reactor turns. For this purpose reactor T104 is provided with a number of taps. If the reactor has nine terminals, the taps are arranged to provide coarse and fine adjustments of voltage, and are connected to a terminal board mounted above the reactor. The tap numbers are shown on the terminal board. Two connections are

made to this terminal board; one lead may be connected to tap 1 and tap 2, and the second lead to taps 3 through 9. Any other connections, such as a lead to tap 1 and a lead to tap 2, or a lead to tap 3 and a lead to tap 9, will not result in proper operation. To decrease the a-c voltage, the lead connected to taps 3 through 9 may be moved to the next lower numbered tap, but must not be connected to any tap below 3. To decrease the a-c voltage by a smaller amount, the lead connected to tap 1 may be moved to tap 2, but it must not be moved to a higher numbered tap; if this lead is already on tap 2, move it to tap 1, and then move the other lead to the next lower tap.

If the reactor has eight terminals, one wire should always be connected to terminal 1 and the other lead connected to any terminal from 2 to 8 which will give the desired voltage setting.

TEST AND REPAIR

Figure 15 shows a typical shop arrangement for testing regulators.

A4 should be a 0 - 0.5 scale d-c ammeter

A5 should be a 0 - 1.0 scale a-c ammeter

F1 is a frequency meter

Figure 18 is a typical elementary wiring diagram of a regulator, while Figure 19 is a typical connection diagram

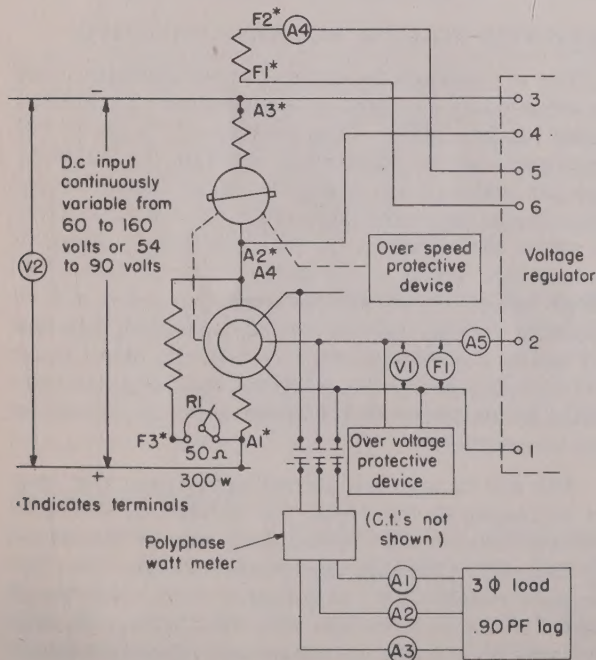


Fig. 15 Amplidyne booster inverter connections to regulator and load

When testing and repairing regulators, the drawings furnished with the regulator should always be used.

INSPECTION

Clean the regulator thoroughly and make a visual inspection. If all component parts appear to be in good condition, make the following tests.

GENERAL TEST

Test the insulation resistance to the frame from terminals 1 and 6 of terminal board E100. Use a 600-volt Megger or similar instrument for this test. If a ground occurs, the faulty part should be replaced.

Connect the regulator to the amplidyne booster inverter as shown in Fig. 15. Start the inverter and bring it up to speed in accordance with separate instructions covering this equipment. Adjust the d-c voltage to approximately the nominal inverter d-c voltage. Set the a-c voltage to the regulator nameplate value by changing taps on the saturated reactor as described under "Adjustments." (CAUTION: The taps must not be changed while the regulator is in operation.) The instruments should read approximately as follows:

V2 Volts D-c	V1 Volts A-c	F1 Freq.	A5 Amp. A-c
72	110	59	0.90
72	115	61	0.90
128	220	59	0.45
128	230	61	0.45

If the frequency exceeds the values indicated, adjustments should be made according to the separate instructions on the amplidyne booster inverter.

If A5 exceeds 1.2 amperes for the low-voltage setting or 0.6 ampere for the high-voltage setting, the component parts of the regulator should be checked as given under "Repair."

Apply full load to the machine and observe its operation. Remove load and observe operation. If satisfactory performance is obtained, no further adjustments are necessary, and the regulator is ready for installation. (Refer to the installation instructions.)

REPAIR

For the few cases where a regulator has a component-part failure that cannot be located by visual inspection, disconnect the wires tabulated below. This is the minimum number of wires that must be disconnected to isolate the individual parts for testing. Disconnecting additional wires will do no harm.

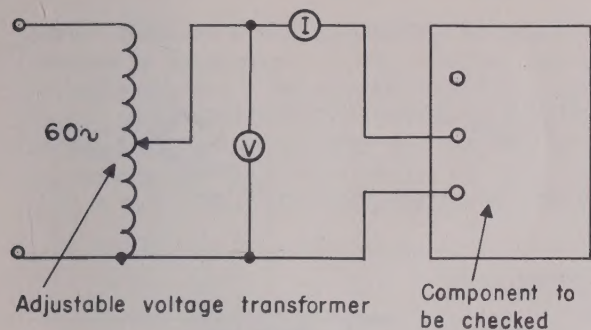


Fig. 16 Impedance check circuit

REGULATOR MODEL NO. 3GNA13A2

PART	TERMINAL	WIRE NUMBERS
T100 Reactor	1	1 and 3
T100 Reactor	3	9
T101 Transformer	6	10
	7	—
T102 Reactor	2	22
T103 Reactor	2	21
T104 Saturated Reactor	Terminal Board E101	42
C101 Capacitor 2 mfd	1	3

OTHER REGULATORS

PART	TERMINAL	WIRE NUMBERS
T100 Reactor	1	1 and 2
T100 Reactor	3	28 and 30
T101 Transformer	6	25
	7	22
T102 Reactor	2	13
T103 Reactor	2	26
T104 Saturated Reactor	1 or 2	40
C101 Capacitor 2 mfd	1	4

IMPEDANCE TEST

See Fig. 16. Using an adjustable-voltage transformer, apply a 60-cycle voltage to the parts listed

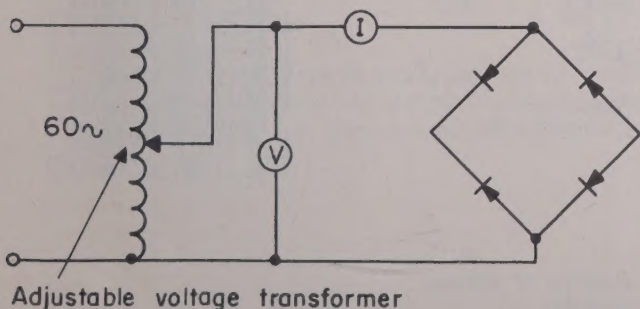


Fig. 17 Rectifier test circuit

below. Increase the voltage gradually to the specified value. Resulting current should be as tabulated.

PART	TERMINALS	VOLT-AGE	CURRENT
S100 Stabilizer	3 and 4	110	$0.25 \pm 30\%$
T100 Reactor	1 and 2	110	$2.25 \pm 20\%$
T101 Transformer	2-4 and 1-3*	110	$0.33 \pm 30\%$ (Exciting Current)
T102 Reactor	1 and 2	110	$0.15 \pm 30\%$
T103 Reactor	1 and 2	30	$1.0 \pm 10\%$
T104 Saturated Reactor	1 and 9 { A6, A7 } 7 and wire { A2 } 12 to C101-1	110	0.15 or less

*Note: Terminals 2 and 4 are jumpered and connected to one side of test voltage. Terminals 1 and 3 are jumpered and connected to other side of test voltage.

It should be pointed out that these are not design tolerances. The current values shown will merely indicate whether the component is still in good working order or has been damaged by shorted turns, etc.

RESISTOR TEST

Check all resistors for continuity.

CAPACITOR TEST

Check the capacitors for open and short circuits.

RECTIFIER TEST

See Fig. 17 on rectifier test. Examine the rectifiers for any brown spots indicating flash-over and for any signs that the metal coating on the disks has melted or softened into droplets. If a rectifier looks faulty, the safest procedure is to replace the unit. If the rectifiers look satisfactory, apply the following test for each of the two rectifiers:

Check for "opens" in the a-c and d-c circuits from the rectifier. This should be true if there are no external connections (terminal board E100) and if the connections previously removed have not been reconnected. The d-c terminals on the rectifier (terminals 2 and 4) are the center and end terminals and are color marked red and black. The a-c terminals 1 and 3 are located midway between the center tap and each end, and are color marked yellow.

Connect a 100-milliamper a-c meter to one of the a-c terminals. Connect a variable-voltage supply to the rectifier and the milliammeter, so that current can be measured. Observe the current as the voltage increases. Do not increase the voltage so that the milliammeter pointer goes beyond full

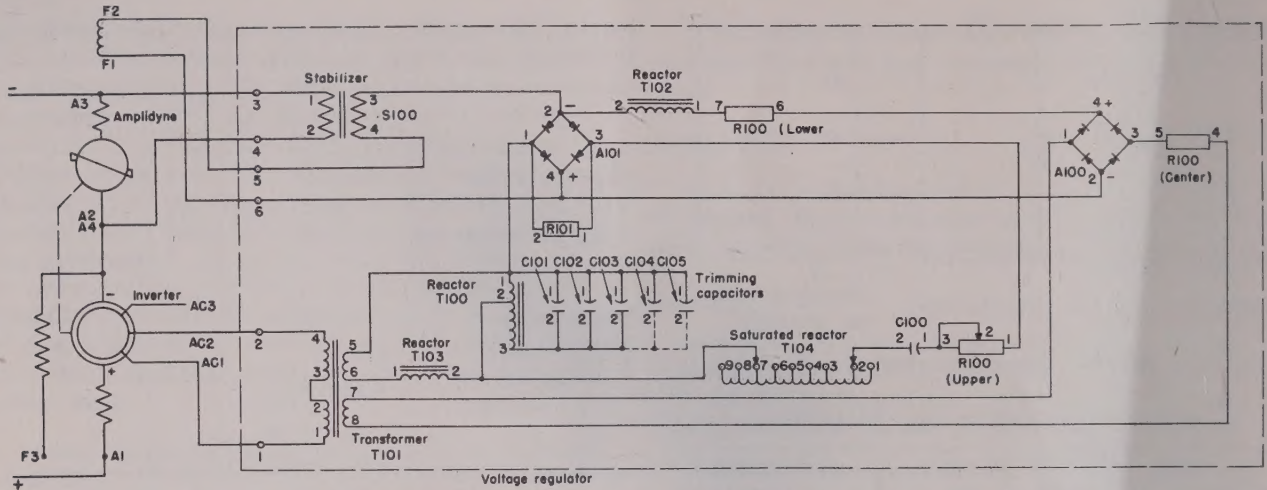
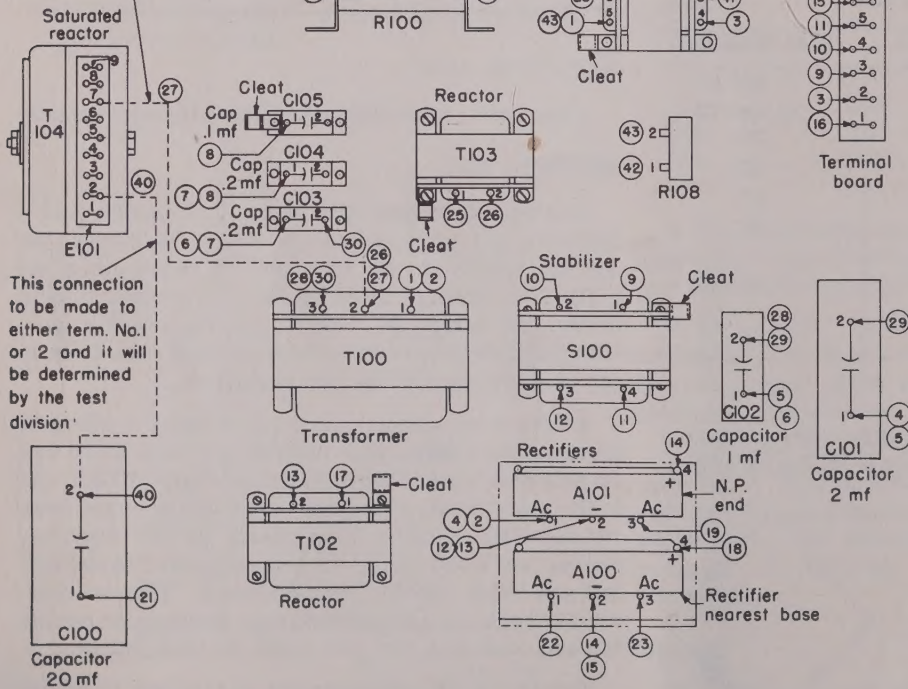
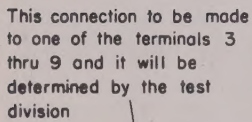


Fig. 18 Typical elementary diagram of voltage regulator (Type GNA-13)



Note: Numbers in circles ○ are wire numbers on the running list.

Fig. 19 Typical connection diagram of voltage regulator (Type GNA-13)

Running List

Wire No.	From	To
1	T100-1	T101-5
2	T100-1	A101-1
3	T101-4	E100-2
4	A101-1	C101-1
5	C101-1	C102-1
6	C102-1	C103-1
7	C103-1	C104-1
8	C104-1	C105-1
9	S100-1	E100-3
10	S100-2	E100-4
11	S100-4	E100-5
12	S100-3	A101-2
13	A101-2	T102-2
14	A100-2	A101-4
15	A100-2	E100-6
16	T101-1	E100-1
17	T102-1	R100-7
18	R100-6	A100-4
19	A101-3	R100-1
20	R100-2	R100-3
21	R100-3	C100-1
22	T101-7	A100-1
23	A100-3	R100-5
24	R100-4	T101-8
25	T101-6	T103-1
26	T100-2	T103-2
27	T100-2	E101-
28	T100-3	C102-2
29	C101-2	C102-2
30	T100-3	C103-2
31	T104-1	E101-1
32	T104-2	E101-2
33	T104-3	E101-3
34	T104-4	E101-4
35	T104-5	E101-5
36	T104-6	E101-6
37	T104-7	E101-7
38	T104-8	E101-8
39	T104-9	E101-9
40	C100-2	E101-
41	T101-2	T101-3
42	R101-1	R100-1
43	R101-2	T101-5

scale. Keep the voltage applied for as long as five minutes if necessary. If the rectifier has been partially deformed, the current should decrease to normal within this time. The test value is 30 milliamperes or less at 90 volts rms for the 20-disk stacks. For the 4-section rectifier (40 disks total), used in Model No. 3GNA13A2 only, the test value is

less than 30 milliamperes at 180 volts. For this rectifier assembly connect the a-c to wire 27 or 28 and to wire 17 or 16. These go to terminals A101-1 and A102-1.

Reconnect all wires within the regulator. Use care in soldering the capacitors. If too much heat travels down to the seal, a leak may result.

TROUBLE SHOOTING CHART

TROUBLE	POSSIBLE CAUSE
A-c voltage abnormally low (more than 10 percent) irrespective of battery voltage.	Linear circuit not supplying power to the loop circuit. Rectifier A100 burned out. 25-ohm resistor R100 burned out. Winding 7-8 of transformer T101 open. Resistor R100 open. Reactor T102 open or burned out.
A-c voltage abnormally high (more than 10 percent) irrespective of battery voltage.	Failure of any components in the nonlinear circuit. T100 open T103 open T104 open R100 open Winding 5-6 of T101 open Rectifier A101, capacitor C100, C101 to C106 shorted or open.
A-c voltage either low or high depending on battery condition. High a-c voltage with high d-c voltage on battery; low a-c voltage with low battery voltage.	Terminals 1 and 2 to regulator loose or disconnected. Transformer primary 1-2 or 3-4, T101 burned out or open. Leads to regulator terminals 5 and 6 loose, broken or disconnected. Stabilizer secondary open or burned out.
Sustained voltage oscillations or hunting.	Leads to terminals 3 and 4 loose, disconnected or broken. Leads from amplidyne to regulator terminals 3 and 4 interchanged. (3 must go to A3, 4 to A4.) Stabilizer primary open or burned out. Too little resistance in adjustable portion of R100.

Any of the above troubles may be due to causes outside the regulator, and in the event of trouble, all other components of the system must be inspected and tested in accordance with separate instructions covering this equipment.

RENEWAL PARTS

When ordering renewal parts, address the nearest sales office of the General Electric Company, specify the quantity required and give the catalog numbers

or describe the required parts in detail. In addition give the complete nameplate rating of the equipment.

WHEN YOU NEED SERVICE

IF YOU NEED TO REPAIR, recondition, or rebuild any electric apparatus, a G-E service shop near you is available day and night, seven days a week, for work in the shops or on your premises. Latest factory methods and genuine G-E renewal parts are used to maintain the original performance of your G-E equipment. For full information about these services, contact the nearest service shop or sales office listed below:

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